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(54) Method of joining an insulated wire to a conductive terminal

Verfahren zum Verbinden eines isolierten Drahtes mit einem leitenden Anschluss

Méthode pour joindre un fil métallique isolé avec un raccord conducteur

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Description

The present invention relates to a method of joining an insulated wire to a conductive terminal and more particularly to a method of joining suitable for integrally joining an insulated wire as unbare to a conductive terminal and forming a metallic joining conductive layer between a core wire of the insulated wire and the conductive terminal.

The present invention relates to a method of joining an insulated wire such as a high heat resisting copper wire having heat resisting temperature of 155-180°C, for example an amide-imide-coated wire, to a conductive terminal such as Cu, or a Cu alloy.

Thermo-compression connecting has been employed for connecting an insulated wire to a U-shaped conductive terminal as described in Japanese Patent Publication No. 18940/1975.

In this method, a current cannot flow because the insulated wire is covered with an insulating coating. For this reason, the insulated wire was connected to the U-shaped conductive terminal by placing the insulated wire in a U-shaped groove of a previously formed conductive terminal, interposing the conductive terminal between an upper electrode and a lower electrode, pressing the conductive terminal, causing a current to flow in both electrodes to bring about heat buildup in the U-shaped conductive terminal, and carbonizing the insulating coating of the insulated wire by means of the electric heating.

In this method, since a resistance welder is employed, not only resistance welding time is short but also a metallic joining conductive layer is not formed between the core wire of the insulated wire and the conductive terminal. In order to compensate for this drawback, the connection between the core wire of the insulated wire and the conductive terminal was conducted by utilizing calking of the conductive terminal through application of force.

The above-described connecting method through mechanical calking brought about a problem with respect to a remarkable lowering in the fatigue resistance as well as in the electrical properties when the joined body was used for a long period of time.

In the above-described conventional mechanical calking connection method, no consideration was given to the formation of a metallic joining conductive layer between the core wire of the insulated wire and the conductive terminal. Therefore, the conventional connecting method had problems also with respect to the mechanical connecting strength, vibration, and electrical properties derived from the vibration. That is, since the conventional connecting method mainly aims at the removal of an insulating coating of the insulated wire, no metallic joining conductive layer can be attained between the core wire of the insulated wire and th conductive terminal.

Under these circumstances, the present inventors have expected that when a joining assistant which melts during carbonization of the insulating coating of the insulated wire is present around the joining area, the molten joining assistant wets a Cu wire as a core wire of the insulated wire which a clean surface has been exposed through the removal of the insulating coating of the insulated wire and then reacts therewith, thereby attaining a metallic joining conductive layer between the core wire of the insulated wire and the conductive terminal.

Further, the present inventors have made various studies on the kind of the insulating coating of the insulated wire and the joining assistant and, as a result, have found that for example, when the insulated wire is an amide-imide-coated wire, a P-containing solder, BAg-1 (JIS), BAg-2 (JIS), etc. which melt at a temperature of 600 to 750°C are suitable as the joining assistant.

More specifically, in the present invention, a joining assistant having a melting point corresponding to the carbonization temperature of the insulating coating of the insulated wire is applied to the conductive terminal, and a metallic joining conductive layer between the core wire of the insulated wire and the conductive terminal is attained simultaneously with the carbonization of the insulating coating of the insulated wire.

As an improvement of the above stated thermo-compression connecting method, a joining method of the insulated wire to the conductive terminal has been employed in, for example Japanese Patent Laid-Open No. 199575/1986. This joining method is adopted merely for the conductive terminal made of Cu.

In this method, a joining assistant such as Cu-Sn alloy, or Cu-Zn alloy is used for forming as a metallic joining conductive layer between a Cu core wire of an insulated wire and Cu conductive terminal. However these alloys are joined in general with a flux. When flux is used, this flux may evaporate during supplied current, the effect according to flux function becomes small. Namely, there can not obtained a joining body having high joining strength.

Further the above stated joining assistant has no element for working as flux therein, accordingly the wetting property of the joining assistant is bad.

In another document DE-A-1640471, it is disclosed that a self-fluxing joining assistant may be used to cover a core then this joining assistant is covered by an insulating coating and thus forming an insulated wire. In this document, the joining assistant is used as a part of the insulated wire.

The present invention therefore seeks to provide a method of joining an insulated wire to a conductive terminal by which a highly reliable conductor is obtainable by the formation of a metallic joining conductive layer between a core wire of an insulated wire and a conductive terminal.

The present invention also seeks to provide a method of joining an insulated wire to a conductive ter-

minal by which a high joining strength may be obtained by the formation of a metallic joining conductive layer between a core wire of an insulated wire and a conductive terminal.

The present invention also seeks to provide a method of joining an insulated wire to a conductive terminal by which a high vibration resistance may be obtained by the formation of a metallic joining conductive layer between a core wire of an insulated wire and a conductive terminal.

The present invention therefore proposes a method of joining an insulated wire to a conductive terminal in accordance with claim 1.

The conductive terminal preferably comprises Cu alloy being at least one of brass, bronze, Cu-Ni, and Cu-Ni-Ag.

The P-containing solder may be disposed on the joining area by a method being at least one of cladding, flame spray, ion injecting and hot dipping, and a film of the P-containing solder has about 20-100 µm thickness.

A resistance welder can be used as a joining device for joining the insulated wire with the conductive terminal in the present invention because it makes possible to conduct heating and pressing simultaneously and to complete joining in a short time. Since joining is conducted in most cases in the atmosphere, a shorter joining time reduces the possibility of reaction with the oxygen, thereby enabling the manufacture of an excellent joined body.

In order further to increase the reliability of the metallic joining conductive layer, it is preferred to adopt a two-stage heating and pressing system in the resistance welder.

Specifically in such a system, in the first stage of the heating and pressing, the insulating coating of the insulated wire is carbonized and the joining assistant is melted. Subsequently, in the second stage, the carbonized insulating coating of the insulated wire is expelled from the metallic joining conductive layer and, at the same time, the joining assistant wets sufficiently the core wire of the insulated wire and the conductive terminal and an excessive joining assistant is expelled so that there is a metallic joining conductive layer between the core wire of the insulated wire and the conductive terminal.

In this case, it is necessary to select the joining assistant in dependence on the insulating coating of the insulated wire. This is because, when the carbonization temperature of the insulating coating of the insulated wire is high, the application of a joining assistant having a low melting point causes the joining assistant to be melted before carbonization of the insulating coating of the insulated wire and to be expelled by pressing, which makes it impossibl for the joining assistant to contribute to the formation of the metallic joining conductive layer between the core wire of th insulated wire and th conductive terminal.

Further, in this case, unfavorably an excessive reaction with the conductive terminal proceeds, which leads to the cracking of the bent portion of the conductive terminal.

On the other hand, when a joining assistant having a high melting point is used, the joining assistant will not melt, so that no good joining can be attained. In view of the above, it is apparent that the insulating coating of the insulated wire and the joining assistant should have substantially the same melting point.

Examples of the joining assistant applicable for an amide-imide-coated wire include those having a melting point of 600 to 750°C, for example, a joining assistant comprising 15% of Ag, 3.5% of P, 9.5% of Sn, and 0.5% of Au with the balance being Cu (P-containing solder having a melting point of about 600°C).

The P-containing solder requires no flux and, therefore, can eliminate the need for conducting washing after joining, which renders it advantageous from the economic viewpoint.

There are many possible materials for the conductive terminal. Among them, Cu, brass, bronze, Cu-Ni, Cu-Ni-Ag.

The above-described joining assistants may be applied by any ordinary method. Various methods can be used for this purpose, and examples thereof include a method which comprises preparing a paste from a powdery joining assistant and applying the paste to the conductive terminal, a method comprising spraying a powdery joining assistant through flame spray, a method which comprises wrapping a foil-shaped joining assistant, a method in which a conductive terminal is previously clad with a foil-shaped joining assistant, and a method of hot dipping etc..

Since the metallic joining conductive layer between the core wire of the insulated wire and the conductive terminal can be formed according to the present invention, the joined body prepared according to the present invention exhibits an excellent joining strength and a low electrical resistance and can be used stably as a conductor (joined body) for a long period of time.

In the drawings :

Figs. 1a, 1b and 1c are schematic cross-sectional views of a fundamental embodiment of the present invention ;

Figs. 2a, 2b and 2c are schematic diagrams showing the applied pressure in the electric heating and pressing ;

Figs. 3a, 3b and 3c are schematic diagrams showing the applied current is the electric heating and pressing ; and

Fig. 4 is a joined body obtained according to the joining method through the present invention.

One embodiment of a method of joining an insulated wire to a conductive terminal according to the present invention and a joined body prepared by the above method will now be described.

A fundamental joining method is shown in Figs 1a, 1b and 1c. Fig 1a is a schematic view of a sate of assembly of the parts. A U-shaped conductive terminal 3 is interposed between an upper electrode 1 and a lower electrode 2, and a joining assistant 4 is previously applied to those sides of the conductive terminal 3 between which an insulated wire 5 is to be placed.

The insulated wire 5 is placed therebetween. The insulated wire 5 is composed of an insulating coating 6 and a core wire 7 made of Cu. In this case, the applied pressure P_a and the supplied current for welding I_a are both null. (see Fig. 2a and Fig. 3a).

Fig. 1b is a schematic view showing a state of a first-stage electric heating and pressing. First of all, a pressure P_b is applied to the conductive terminal 3, which causes a current I_b to flow in the conductive terminal 3 and the conductive terminal 3 to be heated. (see Fig. 2b and Fig. 3b). This brings about carbonization of the insulating coating 6 of the insulated wire 5.

The insulating coating 6 of the insulated wire 5 is heated at a temperature slightly above the carbonization temperature. At that time, the joining assistant 4 is also melted. The molten joining assistant 4 wets the conductive terminal 3 and the Cu core wire 7 of the insulated wire 5 to bring about partial metallic joining conductive layer 8 between the Cu core wire 7 of the insulated wire 5 and the conductive terminal 3.

Fig. 1c is a schematic view of a state of a second-stage electric heating and pressing. A pressure P_c is applied to the conductive terminal 3, which causes a current I_c to flow in the conductive terminal 3 and the conductive terminal 3 to be heated. (see Fig. 2c and Fig. 3c). In this stage, the wetting with the joining assistant 4, further proceeds, and the carbonized insulating coating 6 of the insulated wire 5 is expelled together with an excessive joining assistant 4 from the joining area.

When this stage is completed, the metallic joining conductive layer 8 (also referred to as "metallurgical joining conductive layer") between the conductive terminal 3 and the Cu core wire 7 of the insulated wire 5 exposed through breaking of the insulating coating 6 of the insulated wire 5 is accomplished.

Example 1

BsP_3 (JIS brass) comprising 59.0 to 62.0% of Cu with the balance being Zn was used as a conductive terminal 3, and an amide-imide-coated wire having a Cu core wire was used as an insulated wire 5. A joining assistant 4 comprising a P-containing solder composed of 15% of Ag, 3.5% of P, 9.5% of Sn, and 0.5% of Au with the balance being Cu (melting point : about 600°C) was applied in paste form to the conductive terminal 3, and joining was conducted with a resistance welder by electric heating and pressing.

Example 2 (Comparative Example)

A cold-rolled steel sheet of Ni-plated soft steel was used as a conductive terminal 3, and an amide-imide-coated wire having a Cu core wire was used as an insulated wire 5. A 50 µm-thick foil comprising BAg-7 (JIS) composed of 56% of Ag, 17% of Zn, and 5% of Sn with the balance being Cu (melting point : about 650°C) was used as a joining assistant 4, and joining was conducted with a resistance welder by electric heating and pressing.

Example 3

BsP_2 (JIS brass) comprising 64.0 to 68.0% of Cu with the balance being Zn was used as a conductive terminal 3, and an amide-imide-coated wire having a Cu core wire was used as an insulated wire 5. A joining assistant 4 comprising a P-containing solder composed of 14.0 to 16.0% of Ag, 4.8 to 5.3% of P with the balance being Cu (melting point: about 700°C) was applied in cladding form to the conductive terminal 3, and joining was conducted with a resistance welder by electric heating and pressing.

Example 4

Cu was used as a conductive terminal 3, and an amide-imide-coated wire having a Cu core wire was used as an insulated wire 5. A joining assistant 4 comprising a P-containing solder composed of 4.7 to 6.3% of Ag, 6.8 to 7.7% of P with the balance being Cu (melting point : about 720°C) was applied in frame spray form to the conductive terminal 3, and joining was conducted with a resistance welder by electric heating and pressing.

Comparative Example 1

Connecting of an insulated wire to a conductive terminal was conducted with a resistance welder in the same manner as that of Example 1, except that no P-containing solder was applied.

Comparative Example 2

Connecting of an insulated wire to a conductive terminal was conducted in the same manner as that of Example 2, except that no joining assistant in foil form comprising BAg-7 (JIS) was used.

The joined body or the connected body prepared by joining or connecting in the foregoing Examples and Comparative Examples were each subjected to a tensile test. In the tensile test, the upper portion of the insulated wire projecting from the conductive terminal was cut to determine true joining or connecting strength as much as possible because otherwise the projection portion of the insulated wire might bring about a necking

effect.

As a result, it was found that the connected body wherein no joining assistant was used, i.e., the comparative connected body, causes the insulated wire to be pulled out of the connected area, viz., exhibits an insufficient connecting strength.

On the other hand, the joined body wherein the joining assistant according to the present invention was used brought about breaking of the insulated wire in all of the Examples, viz. had a surely joined area and exhibited a high joining strength.

The microscopic observation of the state of the connected area has revealed that the connected bodies prepared in the comparative Examples have black lines indicating poor connecting at the connecting interface between the conductive terminal and the core wire of the insulated wire, and no metallic joining conductive layer was observed in the connected bodies prepared in the Comparative Examples.

On the other hand, in all of the joined bodies prepared according to the present invention, the joining assistant of several μm was present at the joining interface, and the metallic joining conductive layer between the conductive terminal and the core wire of the insulated wire through the joining assistant was observed.

The reason why the joined bodies according to the present invention exhibit stable joining strength in the above-described tensile test resides in that sufficient metallic joining conductive layer (metallurgical joining conductive layer) is formed through the joining assistant.

Further, with respect to the electrical properties, it was found that in this state, the joined body consistently exhibited very low electrical resistance.

In the embodiments of the present invention, P (phosphorus) in P-containing solder having a film thick about 20-100 μm works as flux function. Therefore, even when Cu core in the insulated wire is oxidized, P (phosphorus) generates phosphid in combination with oxygen in the oxidizing film. The surface of the joined body is made clean an the wetting property of the solder can be promoted. Accordingly, the joined body having high joining strength can be obtained.

Claims

1. A method of joining an insulated wire to a conductive terminal which comprises placing an insulated wire (5) comprising an insulating coating (6) and a core wire (7) between both sides of a conductive terminal (3), causing a current flow between said both sides of said conductive terminal (3) while pressing said conductive terminal (3), and carbonizing said insulating coating (6) of said insulated wire (5) after a joining assistant (4) comprising a metal and being disposed on said insulating coating (6) of said insulated wire (5) is applied to a joining area of said core wire (7) of said insulated wire (5) or said conductive terminal (3), said insulating coating (6) of said insulated wire (5) is removed and said joining assistant (4) is melted through electric heating thereby bringing about a metallic joining conductive layer (8) between said core wire (7) of said insulated wire (5) and said conductive terminal (3) wherein:

   said conductive terminal (3) comprises Cu or Cu alloy, said insulated wire (5) is a high heat resisting, wire having Cu core-wire (7) and said joining assistant (4) comprises phosphorous and a component selected from at least one of the elements Cu, Ag, Sn, Ni, Zn and Au, said joining assistant (4) having a melting point of 500 to 750°C and corresponding to the carbonization temperature of the insulating coating (6), and said conductive terminal (3) is pressed with sufficient force to deform said conductive terminal (3) and expel residues of said carbonization of said insulating coating (6).

2. A method of joining an insulated wire to a conductive terminal according to claim 1 wherein : said conductive terminal (3) comprises Cu alloy comprising at least one selected from brass, bronze, Cu-Ni and Cu-Ni-Ag.

3. A method of joining an insulated wire to a conductive terminal according to claim 1 or claim 2 wherein : said P-containing solder (4) is disposed on said joining area by a method at least one selected from cladding, flame spray, ion injecting, and hot dipping, and a film thick of said P-containing solder (4) has about 20-100 μm.

4. A method according to claim 1 wherein said conductive terminal (3) is made of brass said joining assistant (4) contains Sn.

Patentansprüche

1. Verfahren zum Verbinden eines isolierten Drahtes mit einem leitenden Anschluß, wobei ein einen isolierenden Überzug (6) und einen Kerndraht (7) aufweisender isolierter Draht (5) zwischen beiden Seiten eines leitenden Anschlusses (3) angeordnet wird, zwischen den beiden Seiten des leitenden Anschlusses (3) ein Stromfluß bewirkt wird, während auf den leitenden Anschluß (3) Druck ausgeübt wird, und der isolierende Überzug (6) des isolierten Drahtes (5) verkohlt wird, nachdem eine auf dem isolierenden Überzug (6) des isolierten Drahtes (5) vorgesehene metallhaltige Verbindungshilfe (4) auf einen Verbindungsbereich des Kerndrahtes (7) des isolierten Drahtes (5) oder des leitenden Anschlusses (3) aufgetragen, der isolierende Überzug (6) des isolierten Drahtes (5) entfernt und die Verbindungshilfe (4) durch elektrische Erwärmung geschmolzen ist, um zwischen dem

Kerndraht (7) des isolierten Drahtes (5) und dem leitenden Anschluß (3) eine metallische verbindende leitende Schicht (8) herzustellen, wobei der leitende Anschluß (3) Cu oder eine Cu-Legierung enthält, der isolierte Draht (5) ein hochhitzebeständiger Draht mit einem Cu-Kerndraht (7) ist und die Verbindungshilfe (4) Phosphor und mindestens eines der Elemente Cu, Ag, Sn, Ni, Zn und Au enthält, wobei die Verbindungshilfe (4) einen der Verkohlungstemperatur des isolierenden Überzugs (6) entsprechenden Schmelzpunkt von 600 bis 750 °C hat, und der leitende Anschluß (3) mit einer zu seiner Verformung und zum Ausstoßen von Verkohlungsresten des isolierenden Überzugs (6) ausreichenden Kraft gedrückt wird.

2. Verfahren zum Verbinden eines isolierten Drahts mit einem leitenden Anschluß nach Anspruch 1, wobei der leitende Anschluß (3) eine Cu-Legierung enthält, die zumindest eine aus Messing, Bronze, Cu-Ni und Cu-Ni-Ag ausgewählte Legierung enthält.

3. Verfahren zum Verbinden eines isolierten Drahts mit einem leitenden Anschluß nach Anspruch 1 oder 2, wobei das phosphorhaltige Lötmittel (4) mit zumindest einem der Verfahren Plattieren, Flammspritzen, Ioneninjektion und Schmelztauchen auf den Verbindungsbereich aufgebracht wird und die Filmdicke des phosphorhaltigen Lötmittels (4) etwa 20 bis 100 µm beträgt.

4. Verfahren nach Anspruch 1, wobei der leitende Anschluß (3) aus Messing besteht und die Verbindungshilfe (4) Sn enthält.

Revendications

1. Procédé de liaison d'un fil isolé à une borne conductrice, selon lequel on dispose un fil isolé (5) comprenant un revêtement isolant (6) et une âme (7) entre les deux côtés d'une borne conductrice (3) et on fait circuler un courant entre les deux côtés de ladite borne conductrice (3) tout en comprimant ladite borne conductrice (3) après qu'un auxiliaire de liaison (4) comportant un métal et étant disposé sur ledit revêtement isolant (6) dudit fil isolé (5) a été appliqué à une surface de liaison de ladite âme (7) dudit fil isolé (5) ou à ladite borne conductrice (3), ledit revêtement isolant (6) dudit fil isolé (5) est retiré et ledit auxiliaire de liaison (4) est fondu par chauffage électrique, réalisant ainsi une couche conductrice de liaison métallique (8) entre ladite âme (7) dudit fil isolé (5) et ladite borne conductrice (3), procédé dans lequel ladite borne conductrice (3) est en Cu ou en alliage de Cu, ledit fil isolé (5) est un fil résistant à une chaleur élevée possédant une âme (7) en Cu et ledit auxiliaire de liaison (4) comporte du phosphore et un composant choisi parmi au moins un des éléments Cu, Ag, Sn, Ni, Zn, Cd et Au, l'auxiliaire de liaison (4) ayant un point de fusion de 600 à 700°C, et la borne est comprimée avec une force suffisante pour la déformer et expulser le revêtement isolant.

2. Procédé de liaison d'un fil isolé à une borne conductrice selon la revendication 1, dans lequel : ladite borne conductrice (3) est en alliage de Cu comportant au moins un élément choisi parmi le laiton, le bronze, Cu-Ni et Cu-Ni-Ag.

3. Procédé de liaison d'un fil isolé à une borne conductrice selon la revendication 1 ou la revendication 2 dans lequel : ledit auxiliaire de liaison (4) contenant P est disposé sur ladite surface de liaison par un procédé choisi au moins par revêtement, pulvérisation à la flamme, injection ionique, immersion à chaud, et une épaisseur de pellicule dudit auxiliaire de liaison (4) contenant P est d'environ 20 à 100 µm.

4. Procédé selon la revendication 1, dans lequel ladite borne conductrice (3) est réalisée en laiton, ledit auxiliaire de liaison (4) contient Sn.

FIG. 1a FIG. 1b FIG. 1c

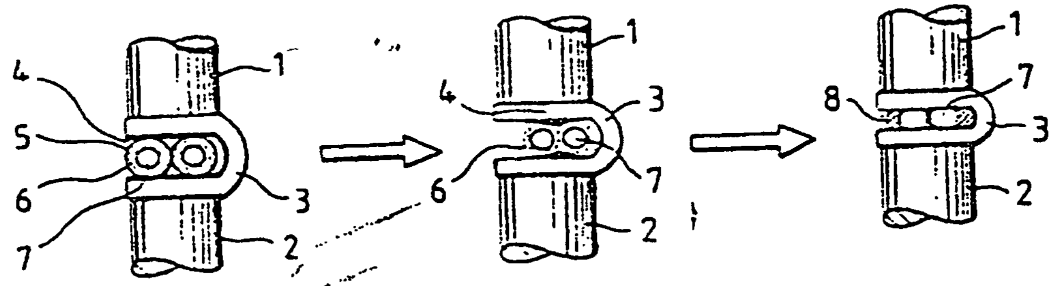

FIG. 2a

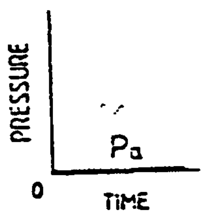

FIG. 2b

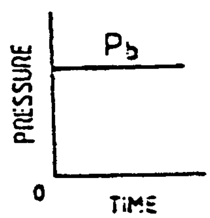

FIG. 2c

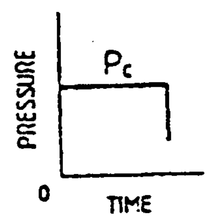

FIG. 3a

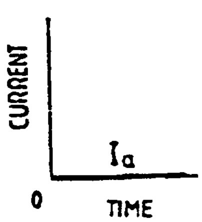

FIG. 3b

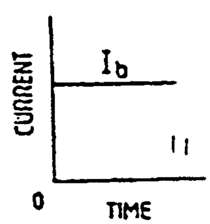

FIG. 3c

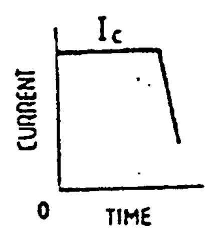

FIG. 4